APPENDIX F

ARTICLES BY F.A. HOUGH ON THE ASA CODE B31.1 SECTION 8

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The gas industry has approved its new safety code
By F.A. Hough, Vice President, Southern Counties Gas Co., Los Angeles
***GAS* — November, 1954**

Actions disclose intent and purpose much more than do words. The gas industry by its *actions* during the past two and one-half years has clearly demonstrated the great importance that it assigns to adequate and proper industry safety standards.

As all readers of *GAS* Magazine know, the gas industry and related industries have been spending a great deal of time, money, and effort in the development of a revised safety code covering gas transmission and distribution facilities. This project was started at the request of the American Gas Association and has been financed by that association. A substantial contribution to a related research project on pipeline pipe has been made by the major pipe manufacturing companies and the AGA. The fitting manufacturing industry, pipe fabricators, pipeline contractors, the insurance industry, and consulting engineering firms have all taken an active part in the development of the revised code. The work of developing the code has been done by an American Standards Association committee, AGA B31, Subcommittee 8, and the new code will be published as an American Standard Code by the American Society of Mechanical Engineers, which is the sponsoring society.

As this is being written, it appears that all necessary approvals of the code will soon be forthcoming and that it can be published in December 1954. Subcommittee 8 and the utility company members of the American Gas Association have approved the latest draft of the code by a very decisive vote. In view of the results of these two ballots, it is expected that formal approval by the AGA, the ASA, and the ASME will be given without delay.

This is the first comprehensive code covering the design, construction, operation, and maintenance of gas transmission and distribution facilities that the gas industry in the United States has had. This code, like all codes of its type, is intended to be a statement of what is generally considered to be good practice in the industry; consequently, many companies will undoubtedly find that most of their current practices conform to the new code. However, I expect that practically every gas transmission and distribution company will find it desirable in the light of this new code to change some of its practices and to adopt new practices which will contribute to improved public safety.

The new code has been developed with the idea in mind that it can, if necessary, be adopted by reference by government agencies having jurisdiction over gas transmission and distribution facilities. By providing a suitable and adequate standard code for this purpose, the industry hopes to avoid having to live under a multiplicity of non-standard state and federal codes, each different from the others and some perhaps ineffective or unduly burdensome. However, this has not been the primary objective of the project. The primary objective has been to make a major contribution to the improvement of public safety as it is affected by gas transmission and distribution facilities by ferreting out the causes of failures of such facilities and setting down for the guidance of the industry, procedures and methods which will tend to reduce the frequency of such failures. Compliance with the new code in good faith will accomplish just this. The benefits to be derived by the industry from this activity will be found in a reduction in accidents and failures and the very important improvements in public relations and public acceptance of our product that will come as a result.

There are compelling reasons why all companies in the industry will want to comply with this code regardless of its ultimate legal status. In my opinion the greatest benefit to the industry and to the public will come if the industry is left free to comply with the code on a voluntary basis. If this is done, operations under the code will be less cumbersome and the industry will be free to make improvements in the code as new materials become available or new information is developed. The industry through operation of its appliance testing laboratories has already demonstrated in a striking way that it can regulate itself effectively in matters affecting public safety.

I hope that the American Gas Association and the regional gas associations will continue to sponsor research having as its primary objective the improvement of the safety of its facilities, and that these associations will continue to sponsor programs and reports that will sustain a high degree of safety consciousness and an awareness of the importance of the industry's practices affecting public safety. The industry's code committee should remain an active and alert committee that will revise or supplant the code frequently as experience operating under it and as new equipment, materials and methods make revision desirable.

For those who have not seen preliminary drafts of the proposed code, a discussion of some of its important provisions is presented in the accompanying box. Many limitations and exceptions to the application of these provisions are set forth in the code but cannot be repeated here for lack of space and time.

It will be noted in the box that provision is made for retroactive application of the code.

Design, construction and testing provisions of the code which produce an improvement in safety commensurate with their cost when applied at the proper time during the design or construction of a facility would usually impose a cost out of all proportion to the benefits derived, if an attempt were made to apply the same provisions to existing installations. This is a fact generally recognized by building officials and others charged with the development of building codes and similar codes concerned with public safety.

It is expected that Subcommittee 8 will remain an active committee for the purpose of providing answers to questions raised concerning the intent of the code, and to revise the code as experience with its use and as new developments require.

The American Standards Association has a systematic procedure for handing inquiries. All requests for interpretations or suggestions for revisions should be addressed to the Secretary, ASA Committee B31, 420 Lexington Ave., New York 17, or to that committee in care of the ASME, 29 W. 39th St., New York 18. In either case the request will be routed to the proper committee or individual for preparation of a reply.

Requests for interpretations or changes in the code for clarification can usually be acted upon promptly. Requests for basic changes in the code or questions that disclose the need for basic changes require more time. When an approved reply to an inquiry involves a change in the code rules, the ruling is made public through the issuance of a case. This is published in "Mechanical Engineering" and also issued to all subscribers to the ASME Piping Code Interpretation Service. Other changes are usually handled by issuing revisions to the code once each year. Suggestions for revisions may originate within the committee itself or from anyone outside the committee. The ASME maintains a revision and interpretation service pertaining to the Code for Pressure Piping. The current annual fee is $2 and it is recommended that users of the code subscribe to this service as the most effective means of keeping up to date.

It is expected that the new code will be published in December and it can be obtained by placing orders with the ASME. The price per copy has not yet been established.

A Discussion of Some Important Provisions in the Code

1. *Qualification of materials and equipment.* All materials and equipment entering into gas transmission and distribution facilities must be qualified as to their safety for the conditions under which they are to be used. In the case of major items, such as pipe and fittings, this can be accomplished by using items that conform to approved specifications listed in the code. Items for which no standard specifications are listed in the code may be qualified by procedures set forth in the code which are simple or complicated depending upon the importance of the item from the standpoint of safety and the type of service it is to be in.

2. *Welding.* The code contains a chapter on welding, which covers preparations for welding, qualification of welding procedures and welders, and the inspection and testing of welds. Both distribution system and transmission pipeline welding are covered. The importance of proper welding procedures and adequate quality control when welding high strength pipe for high pressure service is emphasized. The importance of preheating and/or stress relieving under specified conditions is emphasized. In general the welding requirements correspond closely with those in the new Section 6 of the Pressure Piping Code, which in turn are carefully coordinated with Section 9 of the ASME Boiler and Pressure Vessel Code. API Standard 1104, "A Standard for Field Welding of Pipelines," is acceptable under the code as a field welding specification, if the options in that specification are properly specified in accordance with the code.

3. *Fabrication details.* A chapter devoted to this subject covers flanges, bolting, gaskets, fittings, valves, branch connections, and special components fabricated by welding. A greatly amplified and improved section on branch connections is given. There are also new sections on expansion and flexibility, and on supports and anchors. The importance of providing adequately for the relative movement of underground pipelines in the design of interconnections between such lines is emphasized.

4. *Pipeline design.* Pipeline design procedures prescribed in the new code are similar to the design requirements of the code that is now in effect in that design is based upon the specified minimum yield strength of the pipe rather than upon the ultimate strength, and upon nominal wall thickness rather than minimum pipe wall thickness. The maximum stress level permitted for pipelines in rural and thinly populated areas is the same in the new code as in the old, namely 72% of the specified minimum yield strength of the pipe. At this point, however, the similarity ceases. In the new code, design is based on four location classes. Classification of locations is based on the density of population along the route of the proposed pipeline. A specific method for determining this density is prescribed by the code. These four location classes encompass the entire range from remote, sparsely settled locations on one hand to big city streets on the other. A maximum design stress is prescribed for each location class, the highest being 72% of the specified minimum yield strength and the lowest being 40% of the specified minimum yield strength.

   The maximum working pressure of a pipeline is also limited to a specified percentage of the pipe mill test pressure, and this sometimes becomes the controlling factor. The code prescribes that fabricated assemblies such as mainline valve assemblies, shall be designed for a lower hoop strength than 72% in all cases.

While the provisions of the new code relating design to location of the pipeline vary widely from the existing code, designs based on the new code come closer to conforming to the designs actually used by pipeline companies in recent years than would a design based upon a literal interpretation of existing code.

5. *Installation.* The code stresses the importance of adequate inspection during construction. It emphasizes the importance of avoiding scratches and gouges in highly stressed pipelines and prescribes that when defects are found, they shall be removed. The field repair of such defects is not permitted.

6. *Requirements for testing after construction.* In general the code requires that all transmission and distribution piping be tested after installation and before being placed in service. If the operating pressure is to exceed 100 psi, both a leak test and a test to demonstrate structural adequacy are required. If the operating pressure is to be below 100 psi, only a leak test is required.

   In rural and sparsely populated areas the test to demonstrate structural adequacy may be with gas or air to 110% of the maximum operating pressure, or with water to at least 110% of the maximum working pressure.

   In fringe areas around town and cities no gas testing is permitted. In such locations an air test to 125% of the maximum working pressure or a water test to at least 125% of the maximum working pressure is prescribed.

   In towns and cities, hydrostatic testing is prescribed in all cases where a hoop stress exceeding 30% of the specified minimum yield strength is required during the test. In such locations the minimum test pressure is 1.4 times the maximum operating pressure. Since distribution piping is usually stressed to much less than 30% of the specified minimum yield strength, hydrostatic testing of distribution mains and services is rarely required under the code.

   The code prescribes that in all cases the testing be done with due regard for the safety of employees and the public during the test. It requires that in all cases where air or gas is used as the test medium "steps shall be taken to keep persons not working on the testing operations out of the testing area during the period in which the hoop stress is first raised from 50% of the specified minimum yield strength to the maximum test stress, and thereafter until the pressure is reduced to the maximum working pressure."

7. *Cast iron pipe.* Design requirements for cast iron mains and services conform generally to the requirements of ASA A21.1, A21.3, A21.7, and A21.9.

8. *Compressor stations.* Compressor station, construction, operation and maintenance items affecting safety are covered by the code. Subjects covered include location of site, provisions for escape from fenced areas, electrical facilities, corrosion control, liquid removal ahead of compressors, fire protection, emergency shutdown facilities, engine over-speed stops, over-pressure protection devices, building ventilation, and design of high pressure gas piping.

9. *Pipe-type and bottle-type holders.* The code prescribes that all holders of these types be installed underground. It prescribes permissible stress levels depending upon the location of the facility, clearance between containers, and distances they are located from property lines.

10. *Overpressure protection.* Numerous accidents in the gas industry have demonstrated the importance

of preventing the accidental overpressuring of gas transmission and distribution facilities; consequently, this subject has been given extensive treatment in the code. The extent of this treatment can be indicated by listing here the paragraph headings in the section on "Control and Limiting of Gas Pressure." They are:

a. Basic Requirement for Protection Against Accidental Overpressuring.

b. Control and Limiting of Gas Pressure in Pipe and Bottle Type Holders, Pipelines, and All Facilities That Might at Times be Bottle Tight.

c. Maximum Allowable Operating Pressure for Pipelines or Mains.

d. Qualifying a Pipeline or Main for a New or Higher Maximum Allowable Operating Pressure.

e. Control and Limiting Gas Pressure in High-Pressure Distribution Systems.

f. Maximum Allowable Operating Pressure for High-Pressure Distribution Systems

g. Qualifying a High-Pressure Distribution System for a New and Higher Maximum Allowable Operating Pressure.

h. Control and Limiting of Gas Pressure in Low-Pressure Distribution Systems.

i. Maximum Allowable Operating Pressure for Low-Pressure Distribution Systems.

j. Conversion of Low-Pressure Distribution Systems to High-Pressure Distribution Systems.

k. Control and Limiting of the Pressure of Gas Delivered to Domestic and Small Commercial Customers from High-Pressure Distribution Systems.

l. Requirements for Design of All Pressure Relief and Pressure Limiting Installations.

m. Required Capacity of Pressure Relieving and Pressure Limiting Devices.

n. Proof of Adequate Capacity and Satisfactory Performance of Pressure Limiting and Pressure Relief Devices.

1. *Gas Services and customers' meters and regulators.* The location and type of valves required for service shutoffs are specified. Under some conditions so-called tamper-proof valves are required. The testing of services after they are installed and before they are placed in operation is prescribed. There are basic requirements concerning meter and regulator locations.

2. *Vaults.* Vaults above a specified size housing pressure regulating equipment are required by the code to be ventilated. It is also required that they be of adequate size to permit proper installation and maintenance of equipment.

3. *Operating and maintenance procedures.* The code prescribes that each operating company having gas transmission or distribution facilities within the scope of the code shall:

a. Have a plan covering operating and maintenance procedures in accordance with the purpose of this code.

b. Operate and maintain its facilities in conformance with this plan.

c. Keep records necessary to administer the plan properly.

d. Modify the plan from time to time as experience with it dictates and as exposure of the public to the facilities and changes in operating conditions require.

Some essential items to be included in the plan are listed for each type of facility, such as pipelines, distribution systems, compressor stations, bottle-type holders, and pressure limiting and pressure regulating facilities, valves, and vaults.

1. *Retroactive application.* The subcommittee's intent concerning the retroactive application of the code can be best stated by quoting from the code:

2. "It is *not* intended that this code be applied retroactively to existing installations insofar as design, fabrication, installation, established operating pressure and testing are concerned. It is intended however, that the provisions of this code shall be applicable to the operation, maintenance, and uprating of existing installations."

Part 1 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

A Background Discussion by Fred A. Hough [1]

I have accepted the invitation of the editors of *GAS* Magazine to write a series of articles on the new American Standards Association code for Gas Transmission and Distribution Piping, ASA B31.1 Section 8. This code has been developed over a period of two and a half years by an aggregation of experts that is unique in the annals of gas industry technical committees because of the caliber of the membership and the wide scope of interests represented.

Because of the limitations that are of necessity placed on the language and material entering into a code, much valuable information and discussion that went on during the development of the code is not to be found within the finished document. The editors of *GAS* Magazine have felt that a series of articles presenting some of this background material, if published during the period when the code is first made available to the industry and is first being placed in use by the industry, would help those who are faced with the task of using the code and are endeavoring to bring company practices and policies in line with the code.

These articles are intended to call attention to the code itself and to specific items in the code, and to give background material concerning the thinking of the committee and some of the facts that led the committee to its conclusions. It is hoped that they will aid those who use the code to understand it and to recognize the significance of some of its provisions. On the other hand, these articles have no official status. They are not intended to amplify or interpret the code. The wording of the code must stand by itself. If users of the code wish official interpretations or clarifications, these can be had by writing to the secretary of committee ASA B31 at 420 Lexington Ave., New York 17, or to the committee in care of the American Society of Mechanical Engineers, 29 W. 39th St., New York 18.

When, as a result of such inquiries, an official interpretation of the meaning of the code is given or revisions of the code are made, these are reported as cases and published in Mechanical Engineering and other magazines as they may desire to do so.

Those who want to be automatically notified of any such changes may subscribe (for a fee) to the ASME Revision and Interpretation Service pertaining to the Code for Pressure Piping.

This first article will be confined to a discussion of the first two major subdivisions of the code—the Foreward and the section on General Provisions and Definitions. In these two sections the history of the code is recounted, the mechanism and procedures involved in getting official interpretations and revisions is described in detail, and the scope and intent of the code is defined.

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[1] Fred Hough was chairman of ASA B31, Subcommittee 8, which developed the code. Formerly vice president of Southern Counties Gas, he is now a consulting engineer with the Bechtel Corp.

The history and development of the code
***GAS* — January, 1955**

Perhaps the first and most important thing for all users of the Code for Gas Transmission and Distribution Piping to understand is the basic purpose and intent of all safety codes of the type we are considering here. All codes of this type are intended to be a statement of what is generally considered to be good practice within the subject industry, concerning design, construction, operation, and maintenance practices affecting public safety. Perhaps the true nature of such a code can be best explained by pointing out some of the things that such codes are not.

In the first place, such a code is not a law. Since it is intended to be a statement of what is generally accepted to be good practice, it is naturally written by engineers, operators, and managers, who, as a result of their experience and their knowledge of the engineering and scientific principles involved, state what they agree is good practice from the standpoint of public safety. While members of the learned and highly respected legal profession greatly assisted individual members of the committee by explaining to them the legal significance of the code, they did not say or imply that active participation on their part in the drafting of the code was either necessary or desirable. Any such participation would be apparent to a court before which the code was presented as a statement of what is generally accepted as good practice in the industry and the effectiveness and acceptance of the code as such might thereby be impaired. On the other hand, if a code is developed by a competent and truly representative committee and is accepted by an overwhelming majority of the industry, as ours has been, it then has very important legal significance as a statement of what is generally considered to be good practice within the industry, and as such cannot be safely ignored regardless of whether or not it is adopted by reference as such a statement by government agencies having jurisdiction.

Since a code is merely a statement of what is generally accepted to be good practice, it cannot and should not attempt to say who is responsible for complying with such practice in any specific case. For example: Let us assume that the code states that a pipeline, if installed in a certain type of location and under a specified set of conditions, shall be tested in a manner described in detail in the code. The code in doing this has stated what is good practice under the circumstances; however, the question as to who should make the test or who is responsible if a test is not made and a pipeline failure occurs as a result, is not a matter which the code can or should attempt to state. That is a matter of law and contractual relationships. Consequently, the code committee has very properly avoided stating who should be responsible for carrying out a prescribed practice. It simply states the practice.

Furthermore, since a code states what is generally accepted good practice, it cannot include good practices that are not generally accepted. Consequently, new practices that some may feel are far superior to old practices cannot get into a code until the industry generally has been convinced that the new practices are acceptable. Generally speaking, to be acceptable a practice must not only be sound from a technical standpoint but it must be considered necessary in the light of the industry's experience from a public safety standpoint. Because of these limitations, many superior practices, which under some conditions at least are highly desirable, are not prescribed in the code.

This brings us to a discussion of the significance of the word "minimum" in such statements as the following, which, incidentally does not appear in our code: "The standards and specifications cited herein are minimum requirements." Many public officials and others have the impression that a minimum requirement is not necessarily an adequate requirement; consequently this wording has been avoided in Section 8 and has been replaced by the statement: "The requirements of Section 8 are adequate for safety under conditions normally encountered in the gas industry. Requirements for abnormal or unusual conditions are not specifically provided for, nor are all details of engineering and construction prescribed. It is intended that all work performed within the scope of this Section shall meet or exceed the safety standards expressed or implied herein." While this statement is longer, I believe it is better than the one involving the word "minimum," as it more clearly states the intent of the committee.

It should be emphasized here that our code was not written to be used as a specification. A specification covering for example, the construction of a pipeline, is intended to be an essential and integral part of a contract between the owner and the construction contractor. As such it spells out in detail the contractor's and the owner's duties under the contract. A specification is usually written with a specific job in mind, consequently it can be much more explicit concerning most items than the code can be. The code in many cases gives a number of options. The owner may not wish to give all of these same options to the contractor, but may wish to specify one. While one requirement in a construction contract might be that all work shall be done in compliance with the code, in most cases the owner will wish to spell out in detail which specific options available in the code are to be used, and in many cases may wish to prescribe more elaborate and expensive requirements than are prescribed by the code, because of special or unusual conditions of the job.

While talking about specifications, it would be well to discuss briefly the incorporation of standard specifications by reference in our code. Through the standardization activities carried on by the American Standards Association, the American Society for Testing Materials, the American Petroleum Institute, and others, many of the products widely used in American industry are made to conform with certain standard published specifications. Many of these specifications are incorporated by reference in our code. Sometimes people become confused as to the relationship between these specifications and the code. Perhaps the simplest general statement that can be made to clarify this matter is that a specification is intended to fully describe a material or piece of equipment and to specify the tests and tolerances to be applied to determine whether a given sample fits the description accurately. By the use of such a specification a purchaser can conveniently describe in great detail the material or equipment he wishes to order.

Our code, on the other hand, prescribes conditions of use to which items complying with standard specifications can be put. It is the responsibility of a code committee to examine each of the material and equipment specifications incorporated in the code to see to it that such specifications produce materials or equipment that are suitable for the uses for which they are to be put under the code and to see whether adequate standards of quality control are prescribed by the specifications to insure an adequate degree of public safety. While many specifications are drawn up with conditions of use in mind, this does not relieve the code committee of determining whether new uses or new conditions have arisen which make the specification inadequate.

Paragraph 804.6 of the code states: "It is not intended that this code be applied retroactively to existing installations insofar as design, fabrication, installation, established operating pressure, and testing are concerned. It is intended, however, that the provisions of this code shall be applicable to the operation, maintenance and up-rating of existing installations."

The question of the possible retroactive application of the code by government agencies is one which frequently comes up. The code committee, of course, has no way of controlling the way in which the code is used; however, it should be clearly understood that in drafting this code the committee did not intend that it should be applied retroactively, except as stated above. Obviously everyone who spends dollars to achieve safety wants to make the greatest possible improvement in safety per dollar expended. Practices regarding design and construction which give added safety are prescribed by the code because the improvement in safety is commensurate with the cost. However, in many cases, if the same practices were prescribed for existing installations, the costs involved would be very great and out of all proportion to the improvement in safety achieved. It is evident, because of this fact, that no code written with the intent that it be applied only to new installations should be applied without modification and change, retroactively to existing installations. If there is need for improving the safety of existing installations, this matter should be considered as a separate problem and the most practical and effective solution developed for that problem.

There are significant comments to be made about the definitions of terms given in the section on General Provisions and Definitions; however, these will be left for later articles covering the specific sections of the code to which the definitions apply. In the next article we will discuss Chapter I of the code on Materials and Equipment.

Part 2 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

Materials and equipment: Chapter 1 of the code
***GAS* — February, 1955**

The basic requirements of the code regarding materials and equipment that become a permanent part of a gas transmission or distribution piping system is stated in paragraph B10.1, which says, "It is intended that all materials and equipment that will become a permanent part of any piping system constructed under this code shall be suitable and safe for the conditions under which they are used. All such materials and equipment shall be qualified for the conditions of the use by compliance with certain specifications, standards, and special requirements of this code, or otherwise as provided herein."

Standard specifications

Through such organizations as the American Standards Association, the American Society for Testing Materials, the American Society of Mechanical Engineers, the American Petroleum Institute, the American Welding Society, the American Waterworks Association, the Manufacturers Standardization Society of the Valve and Fitting Industry, standard specifications have been developed to which some materials and equipment entering into gas transmission and distribution systems are manufactured. These standard specifications prescribe in precise terms the chemical and physical properties and the dimensional tolerances of material or equipment manufactured under them.

In many cases they also prescribe the tests that shall be used to determine compliance with their specifications.

These standard specifications serve very useful purposes. They relieve the purchaser of the need for developing specifications of his own, a job for which he is usually not technically qualified. However, probably the most important benefit deriving from these standard specifications is the manufacturing standardization which they make possible. When standard specifications are generally used in an industry, manufacturers can design and manufacture their products to meet a few standard specifications. If no such specifications existed they would have to manufacture to many non-standard specifications, which would increase their costs and consequently their price to the purchaser.
While most specifications are developed with some specific use of the produced in mind, generally speaking the limitations on the use are not stated in a specification and it is the responsibility of the purchaser or the code-writing bodies to spell out the conditions of use under which material or equipment manufactured under a given specification is suitable.

A code committee usually cannot give carte blanc approval to a specification for use under all conditions that might be encountered in an industry. Consequently the user always has the obligation of determining whether the specifications approved by a code are actually suitable under the specific conditions under which he proposes to use the item.

Standard specifications are very important to manufacturers. Consequently, they take a very active part in their development and usually their interest is greater and more sustained than the interest of the user groups. Therefore, standard specification committees tend to be dominated by the manufacturers and the tendency is for the tolerances prescribed in a specification to be broad enough so as to reduce to a minimum the rejects which a manufacturer will have. This very often results in the tolerances in a specification being so broad that the user cannot be sure that material or equipment purchased under the specification is going to be suitable for his specific use.

Line pipe specification

Consider the API 5LX specification for line pipe, for example. This specification was developed to meet the natural gas transmission industries' need for pipe with high yield strength. Until it was recently revised, there were no chemistry limits specified for grades higher than X-42. As a result, a purchaser of pipe manufactured under 5LX-52 might obtain pipe that is readily weldable under the field conditions under which the pipe must be welded, or he might obtain pipe that was not weldable except by special procedures. Consequently, the user had to be alert to this situation and be prepared to use special welding procedures if difficulties were encountered.

Through the efforts of Subcommittee 8 and the cooperation of the API pipe specification committee and the pipe manufacturers, this defect has been partially eliminated through the inclusion of limitations on chemistry in the latest edition of API 5LX published in November, 1954.

The important point here is that a manufacturing problem was allowed to influence the specifications to the point that they no longer protected the user in one very important respect, and too, a standard specification sometimes does not specify some property which is very important to the user. For example, the standard line pipe specifications do not include any impact test requirements. This is an important property of the pipe when used at low temperatures and it is therefore necessary for the user to recognize that when conditions exist that demand good low temperature impact properties, he cannot look to the standard specifications for protection.

A specific reference to a problem of this type is contained in Section 814, which says, "Some of the materials conforming to specifications approved for use under this code may not have properties suitable for the lower portion of the temperature band covered by this code. Engineers are cautioned to give attention to the low temperature properties of the materials used for facilities to be exposed to unusually low ground temperatures or low atmospheric temperatures."

Section 811.21 of the code says, "Items which conform to standards or specifications listed in this code may be used to *appropriate applications* as prescribed and limited by this code without further qualifications." (Italics mine.)

The point which I have been trying to emphasize thus far in this discussion is that while standard specifications are very useful and helpful, it behooves a code committee and a user to examine such specifications critically to see if they really give adequate protection and cover all of the properties which are important in the use under consideration.

Some people believe that only materials and equipment conforming to standard specifications should be permitted by the code in gas transmission and distribution systems. While this might be a desirable policy at some distant future time when both code writing and specification writing have developed to a greater extent than they have now in the gas industry, Subcommittee 8 did not adopt this policy at this time for numerous reasons. Among these are: (1) Standard specifications do not exist for all materials and equipment used in gas transmission and distribution piping systems. (2) As we have pointed out above, standard specifications by themselves do not assure safety. In many cases, a modified specification designed to meet some special condition of use will be better from a safety standpoint than standard specification. (3) The use of new materials or equipment would be delayed for months or even years if the code required that they must be built to a standard specification. It sometimes takes that long to develop such a specification. Furthermore, without experience in actual use it is difficult or impossible to develop a really satisfactory standard specification. (4) If every item entering into a gas transmission or distribution system, no matter how small or unimportant from a safety standpoint, had to conform to a standard specification, a great deal of unnecessary and cumbersome red tape would be created. (5) Gas utilities and pipeline companies often find it necessary to retire from service material or equipment that is in satisfactory condition for reuse. In many cases the original specifications under which the material or equipment was manufactured are not known or are now obsolete. There are, however, uses to which such material can be put which are entirely safe and represent good engineering. Consequently the code prescribes a procedure whereby such material can be qualified for use.

The code imposes a specific obligation on the user to determine the suitability of materials and equipment that he uses. Paragraph 811.24 says in part, "Materials and equipment not covered by standards or specifications listed in this code may be qualified by the user by investigation and tests (if needed) that demonstrate that the item of material or equipment is suitable and safe for the proposed service, and provided further that the item is recommended for that service from the standpoint of safety by the manufacturer."

There are two questions involving pipe specifications which arise so frequently in connection with the design of high pressure, large diameter, gas transmission lines that they are worthy of some detailed discussion here. These two questions involve the specified minimum yield strength of the pipe and the under-thickness tolerance of the pipe. All line pipe specifications prescribe a specified minimum yield strength. The code states that the maximum operating stress in a pipeline shall not exceed a stated percentage of the specified minimum yield strength prescribed in the specifications under which the pipe is purchased from the manufacturer. In almost all cases, tests run on coupons cut from pipe at the mill disclose a higher yield strength than the specified minimum.

This raises the question as to whether the minimum yield strength observed in these tests may be used as a basis of design rather than the specified minimum yield strength. The answer is no for two reasons.

Only a sample

First, the tests represent only a sample of the pipe going into the pipeline. There is a possibility that the weakest pipe was not sampled. Second, it was recognized by the code committee that pipe manufacturers will nearly always produce pipe which has higher values than the minimum guaranteed, so as to reduce their risk of having pipe rejected for failure to comply with the specifications.
Consequently nearly all pipe now in use upon which the industry's experience is based has higher physical properties than the specified minimums under which the pipe was purchased. These facts were taken into account by the committee when establishing permissible stress levels and other conditions of use.

Likewise, pipe wall thickness measurements that indicate that all of the pipe measured has greater thickness than the minimum required by the specifications do not warrant taking advantage of this fact in the design of the pipeline. Here again there is a chance that the thinnest portions of the pipe were not measured, and furthermore, as before, the industry's experience is based on pipe which generally is thicker than the specified minimum thickness contained in the specification under which the pipe was purchased. Again, these facts were taken into consideration by the code committee in setting up stress levels and other conditions of use.

The upgrading of pipe on the basis of random sampling is always prohibited by the code.

Part 3 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

Chapter 2. Welding on completed pipe
***GAS* — March, 1955**

Chapter II of ASA B31.1 Section 8 deals with welding. The investigation by Subcommittee 8 of causes for pipeline failures disclosed that failure of field welds and factory-made girth and repair welds are a more important cause of pipeline failure than many of the subcommittee members had previously thought. In fact, failures of this type constitute the most important single type of pipeline failure resulting from causes originating in the field (as contrasted to causes originating in the pipe mill).

While this record is influenced to a considerable extent by the failure of welds made by processes not now in general use, the record also shows that there has been an important number of failures attributable to welding done since World War II by the manual arc welding process.

Welding on completed pipe

Chapter II of the code and this discussion of that chapter deal only with welding on completed pipe and do not deal with the long seam welding of pipe during manufacture.

The great use of welding in the gas transmission and distribution industry and its relative importance as a cause of failure resulted in careful attention being given to this operation by Subcommittee 8. The subcommittee had in its membership or employed as consultants a number of recognized experts on welding and related metallurgical problems. Among these are Lloyd R. Jackson, Battelle Memorial Institute; Prof. Harry Udin, Massachusetts Institute of Technology; Prof. E.C. Wright, University of Alabama; and Prof. E.R. Parker, University of California.

In addition, the pipe and fitting manufacturers made some of their top metallurgists and welding experts available to the committee. Some of the major pipeline companies gave the committee the results of their recent research on welding.

Sound conclusions

These sources of information, coupled with the experience of the subcommittee members, led, I think, to some very sound conclusions by the committee concerning the cause of current welding difficulties and their elimination.

The most important basic cause is the use of welding procedures that are not suitable when unusual conditions are encountered, such as:

1. High pipe chemistry.
2. Adverse weather conditions, such as low atmospheric temperatures or wind.
3. Making of repairs to pipe or the welding of small attachments to pipe.

Other sources of difficulty have been the use in some cases of inadequate standards of skill and quality, careless workmanship, coupled with inadequate inspection, and improper design of some joints.

To proceed now to a more detailed discussion of these causes of difficulty:

The high pipe chemistry problem is one that is usually not encountered, but it can occur unexpectedly and, by virtue of its unexpectedness, cause trouble on a pipeline construction job and in the subsequent testing of operation of a pipeline.

This problem arises from the demand of the gas industry for high strength pipe and the lack of adequate chemistry limits in the API5LX specifications.

The weldability of carbon steels used in high-strength pipe manufacture is related to their carbon equivalent $\left(C + \frac{MN}{4}\right)$. The chemistry limits of weldability found for ordinary field practices are variously stated by welding engineers to be $C + \frac{MN}{4} = .60$ or $C + \frac{MN}{4} = 6.5$

The new API5LX specifications published in November 1954 contain chemistry limits for 5LX46 and 5LX52 pipe as shown in *Table1.*

TABLE 1. CHEMISTRY LIMITS

	Seamless		**Plate Pipe Cold Expanded**	
	Ladle	**Check**	**Ladle**	**Check**
Carbon, max.	.32	.35	.28	.32
Manganese, max.	1.35	1.40	1.25	1.30

Seamless pipe on the high side of the limits permitted by this specification will have a carbon equivalent of $.35 + \frac{1.40}{4} = .70$.

Likewise, cold expanded pipe complying with this specification can have a carbon equivalent as high as $.32 + \frac{1.30}{4} = .645$.

Border line

It can be seen, therefore, that even the new specification API5LX, which for the first time imposes chemistry limits for X46 and X52 pipe, includes pipe which is on or beyond the border line of weldability by ordinary field procedures.

In order to avoid exceeding the chemistry limits imposed by the new specifications, pipe manufacturers will, of course, aim at a carbon and manganese content considerably below the specified limits and only a small percentage of the total pipe produced will have carbon and manganese contents closely approaching the specification limits. However, the unavoidable variations in chemistry inherent in the pipe-making process will result in some pipe having chemistry at or near the high limits of the specification. In the field there is no way of differentiating this high chemistry pipe from the rest. If it is welded by some widely used procedures during adverse weather conditions a seriously defective weld can result.

Adverse weather

Consider now the effect of adverse weather conditions. Rapid cooling of a weld in high-strength pipe is objectionable. It causes under-bead cracking and lack of ductility. If welding is done in cold weather, the pipe welded will be cold and consequently the rate at which the weld and adjacent metal cools is high. Wind intensifies this effect.

The placing of a small weld on a large mass of cold pipe metal is bad because of the rate at which the large mass will conduct heat away from the weld. This is the reason why the repairing of defects in large pipe, either in the pipe plant or in the field, often leads to trouble. Even if the original defect, such as a crack, is completely removed by grinding, the repair weld is likely to crack because of the chilling effect on the weld of the surrounding mass of cold metal.

The making of small attachments to large pipe by welding is bad for the same reason.

Faulty design which does not prescribe smooth transition from one cross-section to another where pipes of different thicknesses are joined or where pipe is welded to a thick valve or fitting; or faulty design which results in stress concentration at a weld, all can lead, sometimes, to weld failure.

All of the causes of weld failure thus far discussed are actually the result of poor engineering and are not necessarily associated with unskilled or careless welding (although, of course, a poorly made weld is sometimes a contributing cause of failure).

Having in mind now the important causes of pipeline welding difficulties, what remedies are prescribed or recommended by the code?

Qualified welders

The code prescribes that all pipeline welding be done by properly qualified welders in accordance with a procedure that has been proven by tests to be capable of producing sound welds under field conditions.

If this is done intelligently and the procedure is followed in the field, most pipeline welding difficulties can be eliminated. Some companies who anticipate using their welding procedures in cold northern climates are qualifying their procedures by having test welds made in a cold room. The temperature in the cold room is held to the lowest temperature at which welding will be done in the field. Fans in the cold room are used to create realistic wind conditions. Pipe on the high side of the chemistry of the pipe specification is used. Welds made under these conditions are then subjected to the qualifying tests prescribed by the code. These may be those prescribed by:

- ASME Boiler and Pressure Vessel Code Section IX,
- ASA B31.1 Pressure Pipe Code Section 6, Chapter IV, or by
- API Pipeline Welding Specification 1104.

If alloy steel base metals are involved, either one of the first two codes above must be used.

Under-bead cracking tests, although not prescribed by any of the codes, are very useful in checking the suitability of a welding procedure for use in low ambient temperatures.

Almost all procedures designed for welding in cold weather employ the hot-pass technique. This technique consists of following the stringer bead with the second pass (hot pass) as soon as possible and before the heat picked up by the pipe in the immediate vicinity of the weld has dissipated. On 16-in pipe and larger at least two welders work simultaneously on the stringer bead and second pass so as to maintain as high a pipe temperature as possible.

The code points out the great value of preheating the base metal before welding when low metal or ambient temperatures exist. Preheat to 300°F has been found to be very effective. Preheating reduces the rate of cooling of a weld, thus reducing the hardening and cracking tendencies. It is essential even in warm weather when a small amount of welding is done on a relatively large mass of metal (as, for example, when a repair weld or small attachment is made).

The low-hydrogen electrode can be beneficially employed in welding procedures when the adverse effects of low ambient temperatures or other causes of too rapid cooling must be avoided. However, to get reliable results from this electrode, modified techniques must be used. The rod must be stored so as to prevent either moisture loss or moisture absorption.

The code prescribes joint designs that are free from notch effects and are suitable for field welding conditions.

The code classifies gas piping into two categories insofar as welding inspection, weld test, standards of acceptability, and welder qualification are concerned.

Hoop stress

One category involves piping to operate at a hoop stress greater than 20% of the specified minimum yield strength of the pipe, and the other involves piping to operate at lower hoop stresses. In the former case, the requirements of any one of the three codes listed above must be followed.

In the case of the lower stress level category, into which nearly all distribution piping falls, less exacting but adequate standards are prescribed. Compliance with the new code will require that all gas distribution companies and their contractors qualify their welding procedures and their welders. Many such companies have not done this in the past.

Part 4 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

Chapter 3. Piping and Fabrication
***GAS* — April, 1955**

Chapter 3 of the 1995 edition of the ASA Code B 31.1 Section 8 Gas Transmission and Distribution Piping carries the title, "Piping System Components and Fabrication Details." The general content of this chapter and its purpose can best be indicated by quoting from the code. "The purpose of this chapter is to provide a set of standards for piping systems covering (1) specifications for and selection of all items and accessories entering into the piping system other than the pipe itself; (2) acceptable methods of making branch connections; (3) provisions to be made to care for the effects of temperature changes; (4) approved methods for support and anchorage of piping systems, both exposed and buried."

Chapter 3, (and Chapter 2 on welding discussed in our March article), was developed by a sub group under the Chairmanship of F.S.G. Williams who is manager of engineering standards for Taylor Forge and Pipe Works.*

The basic principle upon which Chapter 3 is based is stated in Paragraph 831 as follows, "All components of piping systems including valves, flanges, fittings, headers, special assemblies, etc., shall be designed to withstand operating pressure and other specified loadings with unit stresses not in excess of those permitted for comparable material in pipe in the same location and type of service."

While this is a comparatively simple statement, it is not always simple to comply with it. This Chapter does not deal with simple cylindrical pipe shapes, but with more complex shapes. Furthermore, the valves, fittings, branch connections, etc. are usually subjected to so-called secondary stresses (stresses other than those produced by internal fluid pressure) which may be of more importance than the hoop stress resulting from internal fluid pressure. In many cases, the secondary stresses cannot be accurately calculated. These factors all require that careful engineering be applied.

The studies made by Subcommittee 8 of transmission facilities failures indicated that the industry has from time to time had difficulty with valves, fittings, branch connections, etc. Much of this difficulty arose from the use of items that have been superseded by welded construction and are for the most part obsolete. However, the experience of committee members and the studies made by the committee indicate that "modern" all welded construction involving both field fabricated fittings and reinforcements, and manufactured fittings and reinforcements, have caused sufficient trouble to indicate that there is need for improvements in design, fabrication techniques, and testing.

Branch connections

* The gas industry has benefited greatly from the time and effort that Mr. Williams has devoted to the development of Section 8, both by his contributions of engineering to Chapters 2 and 3 and by is assistance and guidance as chairman of the Pressure Piping Code Committee B31 in the organization and direction of Subcommittee 8. Mr. Williams was ably assisted in the development of Chapter 3 by Arthur McCuchan of Tube Turns, E. O. Dixon of Ladish, W. P. Kliment of Crane Co., L. W. Kattelle of Walworth Co., and by a number of pipeline engineers from the membership of Subcommittee 8 who have had experience in the design construction, and operation of compressor station piping and other complex piping connected with gas transmission and distribution facilities.

To design and build a field-fabricated branch connection with a large-diameter side outlet for a pipeline to be stressed to 72% of the specified minimum yield strength of the pipe and not have stress levels at the connection exceeding this 72% value in places is not easy, and difficulties encountered with branch connections indicate that in many cases stress levels around such connections exceed safe values. When a sufficient amount of reinforcement is provided for branch connections, the stress level in the crotch can be held down to acceptable values. However when this reinforcement is a saddle or pad, numerous tests indicate that a concentration of stress occurs at the points where tangents to the outside circumference of the pad are parallel to the axis of the header.

In these two regions the stresses resulting from the tendency of the pipe to bend around the edges of the reinforcement are directly additive to the hoop stress. Consequently, if the hoop stress in the mainline pipe is at 72% of the specified yield, a branch connection of this type will produce localized stresses in excess of the limit set by the code.

The code describes or recommends a number of things which if properly done will eliminate this branch connection difficulty. In the first place, the code requires that heavier-wall header pipe be used in those locations where branch connections are most frequently required—specifically, at compressor stations and in mainline fabricated assemblies such as those at mainline valves. In the latter case, the maximum hoop stress permissible in the mainline pipe is 60% of the specified yield strength of the header pipe, and in the case of compressor stations the maximum permissible hoop stress is 50% of the specified minimum yield strength of the header pipe. In the second place, forged tees or full encirclement type reinforcements are recommended whenever the ratio of the design hoop stress to the minimum specified yield stress in the header exceeds 50% and the diameter of the branch connection exceeds 25% of the diameter of the header.

Two types of full encirclement reinforcement are approved by the code. One is designed so that the branch connection can be welded to the reinforcement and does not have to be welded to the header pipe. The other is designed so that the branch connection must be welded into the header pipe and to the reinforcement. In this latter case, however, the welding of the reinforcement to the header pipe with a fillet weld around the header pipe at the end of the reinforcement is optional.

The problem of preventing serious stress concentrations around branch connections is reduced to some extent if ductile pipe and reinforcing materials are used and a pressure test is put on the piping assembly to a considerably higher pressure than the maximum operating pressure. Under these conditions, yielding will occur at points of important stress concentration during the pressure test and the assembly will assume a shape that tends to smooth out the stress pattern. Thereafter, a greater margin between operating stresses and stresses required to produce failure will exist in highly stressed areas than would have been the case had no yielding occurred.

All members of the committee were in general agreement that ductility is a highly desirable property for pipe in compressor stations and in other locations where complex assemblies must be used and where temperature changes vibration and other causes produce secondary stresses that might cause trouble around branch connections. However, the committee did not succeed in stating a code requirement acceptable to all members of the committee that would give effect to this objective. There is, however, little doubt that compressor station designers have assigned, and will assign in the future, considerable importance to ductility in selecting pipe for use in compressor stations, process plants, and other locations where complex assemblies are necessary.

This discussion of the stress concentrations around the branch connections has thus far dealt only with stress concentrations resulting from the intensification of the hoop stress in the pipe. This is only part of the problem and in many cases the less important part. Many branch connections are subjected to external forces. These are usually the result of relative movement between the header pipe and the equipment or pipeline to which the branch connection leads. Branch connections must be designed to take care of these external forces. The problem can be minimized by taking steps to reduce the external forces. This can be done by providing flexibility in the branch piping sufficient to take care of the relative movements involved or by anchoring the header pipe and everything to which it is connected so that little or no relative movement occurs.

Because of the restraint induced by the soil friction, a point on a long, straight buried pipe that is several hundred feet from the end of the pipe or from a bend in the pipe does not move as a result of changes in temperature of the pipe. A branch connection placed at such a point will consequently not move with changes in temperature, and therefore if the facility to which the branch connects is also firmly anchored no problems arise as a result of relative movement. However, if a branch connection is placed near the end of a straight capped buried pipe, the bearing power of the soil at the end cap will not be sufficient to prevent its longitudinal movement. Thus a movement of several inches may occur as the result of normal changes in temperature. A rigid pipe connection to a facility that does not move or might even have a tendency to move in the opposite direction, is almost certain to cause serious trouble.

The solution here, as has already been mentioned, is either to firmly anchor the pipeline and other facilities involved or to provide flexibility in the inter-connection, which will prevent overstressing of the branch connection on the header pipe. When large diameter pipelines are involved, big anchors presenting a large area to the soil are necessary. Situations of the type under discussion here arise where loop lines of limited length are interconnected to the original pipeline. They also occur sometimes at scraper traps and at mainline connections to compressor stations. The rather large fluctuations in pipeline temperature that occur at the discharge of a compressor station, particularly at those that do not aftercool the gas, sometimes cause trouble. This results from the hot pipeline on the discharge of the station expanding backward into the station and overstressing branch connections or equipment to which it is attached in the station.

It became apparent during the progress of the work of Subcommittee 8 that there is much to be learned regarding secondary stresses in pipelines. Knowledge of the conditions that produce such stresses became increasingly important as we progressed to design practices for the larger diameter pipelines. This led Subcommittee 8 to develop a plan for a secondary stress research program and to recommend the program to the pipeline research committee of the American Gas Association. As a result, an active committee of the American Gas Association is now proceeding with this valuable and much-needed research with the financial backing of that association.

Most of the experimental work is being done at Battelle Memorial Institute. So far, the experimental work has been focused on a study of stresses around reinforced branch connections under internal pressure, together with various types of external loads, i.e., forces applied to the branch and acting parallel to the axis of the header, and forces applied to the branch and acting perpendicular to the axes of both the branch and the header.

This program is an extension of work on branch connections instituted several years ago at Battelle by five pipeline companies.

The fitting manufacturers are taking an active interest in this work and have agreed to make their own related research work available to the AGA committee.

Other phases of the secondary stress problem which it is hoped the AGA committee will eventually study are:

1. Stresses resulting from backfill.

2. Stresses resulting from non-uniform bearing on the ditch bottom.

3. Longitudinal stresses in buried pipelines. In view of the fact that buried lines are fully restrained in some places, partially restrained in others, and restrained not at all in others, makes this a much more complex problem than many pipeline engineers realize. The idea that the longitudinal stress in a buried pipeline is ½ the hoop stress is wrong more times than right; and such an answer may be either too high or too low.

4. Stresses resulting from pipe being out-of-round.

Part 5 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

Relating design of facilities to the requirements of the location
***GAS* — May, 1955**

Our earlier articles in this series on the 1955 edition of the American Standard Association Gas Transmission and Distribution Piping System Code (ASA B 31.1 Section 8) dealt with the qualification of materials for use in such systems, the qualification of welding procedures and welders, and the design of piping system components, such as branch connections.

We come now to Chapter IV of the code, which deals with the design, installation and testing of pipelines, distribution systems, compressor stations, and pipe-type holders, and which is the most extensive in the book. This article will be limited to a discussion of the general approach used by the committee in relating the design of gas transmission and distribution facilities to the specific locations in which they are to be installed and to a discussion of the provisions of the code regarding the design of high pressure transmission pipelines. Later articles on Chapter IV will cover the installation and testing of pipelines and pipe-type holders, the design, installation and testing of compressor stations and the design, installation and testing of distribution systems.

The two problems that warrant major consideration here are those connected with the selection of locations for natural gas transmission lines and the specification of hoop tress levels that are suitable for the locations in which the pipeline is to be placed. These two factors have a major effect on cost and they are among the many factors affecting public safety. They are, consequently, among the most important problems considered by Subcommittee 8.

The basic conclusions reached by Subcommittee 8 regarding these two problems are the same as the conclusions reached by the preceding committees that drafted the existing Gas Transmission code. The revised code, like the old code, limits the maximum operating hoop stress in a pipeline to 72% of the minimum yield strength specified in the pipe purchase contract and the new code, as well as the old code, requires that this stress level be reduced where the pipeline is located in densely populated areas. The new code differs from the old in the method prescribed to determine the locations where changes in operating hoop stress levels are necessary in the interest of public safety. In this respect, the new code reflects more closely actual current practice in the design of pipelines than does the old.
By and large, the old code permitted a maximum operating hoop stress of 72% of the specified minimum yield strength of the pipe in all locations except those inside the incorporated limits of cities and towns. Within those limits a maximum hoop stress of approximately 50% of the specified minimum yield strength of the pipe was specified. This method of designating where stress levels shall be changed has the virtue of being specific and subject to only one interpretation. However, it does not produce sensible results in many cases. In numerous metropolitan areas today there are districts outside the incorporated limits of towns and cities which are highly developed and have a population density typical of those inside the limits of many towns and cities. In other places, the boundaries of cities extend into remote mountainous areas for the purpose of protecting water rights, or for other reasons, and there is no reasonable prospect of substantial development in these remote districts. The lack of correlation between the boundaries of cities and population density has made it necessary for pipeline companies to use some criteria other than those set up by the old code for determining their design. Public officials have found fault with that code because of its method of designating where stress levels shall be changed.

The problem of relating hoop stress levels to pipeline locations and defining the limits within which any given stress level should be used proved to be so complex that a sub-group of Subcommittee 8 was appointed to study this problem in detail. This sub-group flew over the routes of a number of pipelines to study the practices followed by pipeline companies in the past. It also obtained aerial surveys of all of the major pipelines in the country. It employed a large engineering consulting firm to analyze these aerial photographs and to make a statistical study concerning population densities along the routes of these lines. The recommendations of this sub-group, with some modifications, were adopted by Subcommittee 8 and are included in the new code.

It was the recommendation of this sub-group that the population density in the general area traversed by a pipeline be used in determining the permissible stress level. The sub-group recommended that, in order to determine the population density in the general areas traversed by a pipeline, a zone ½-mile wide be laid out along the route of the proposed line with the pipeline on the center line of this zone and that the number of buildings intended for human occupancy within this zone be used as an index of population density and that this index be used in defining the areas in which each type of construction may be used. Precise instructions are given in the code for determining the population indices by means of which locations are classified for pipeline design purposes. They need not be repeated here; however, some further discussion of the thinking of the committee regarding the classification of locations may be helpful.

In the first place, it should be pointed out that the ½-mile wide zone used for determining these population indices does not indicate that the committee feels that this is the width of a zone of danger. The ½-mile width was selected because a zone of this width can readily be located on typical airplane photographs used for locating pipelines and because a zone of this width, the committee felt, gives a representative sample of the general area traversed.

It should also be pointed out that it was not the thinking of the committee that the design or operating pressure of a pipeline should be changed as soon as additional houses are added which bring the house count above limits specified for a given design. The committee had in mind, in setting the stress level limits in various locations, that population density at the time of the locating of the pipeline would be used as a criterion for design, but that the design prescribed by the code should anticipate that an increase in population density along the route of the line would occur. Consequently, the design limits are set with some provision for normal increase in population.

However, pipeline designers are cautioned to make additional provision for large increases in population density at the time they design a pipeline to be located in areas near centers of population where new subdivisions or new developments are likely to be located in the immediate area traversed by the pipeline. If, in such situations, liberal provision is not made in the design of the line for future changes in population, conditions may develop that will necessitate a relocation of the line, or a replacement with heavier pipe, or a reduction in the operating pressure.

The committee considered and rejected another method for determining pipeline design requirements along the route of the line. This method would require that the design of the pipeline be changed when it comes within a specified distance of a house or other building intended for human occupancy. The committee rejected this method because it fails to recognize some of the facts of pipeline life.

It is possible, of course, to locate a major portion of a pipeline so that at the time of construction it is more than a specified distance from any buildings intended for human habitation or to use a lower stress-level design in those sections where the specified separation distance cannot be attained at the time of construction. It is not economically feasible, however, to prevent the building of buildings closer to the pipeline than the specified distance after the pipeline has been installed. Furthermore, it is not possible to keep people on highways, and railroads that cross the right-of-way, or farmers the specified distance from the pipeline. To do this, it would be necessary for a pipeline company to acquire in fee rights-of-way several hundred feet wide and to fence these rights-of-way in order to keep people the specified distance away from the pipeline.

The obvious conclusion is that the public cannot be kept a specified distance from a pipeline and, consequently, safety can only be achieved by building into pipelines sufficient safety so that the hazards resulting from people and property being in close proximity to the pipeline are within tolerable limits. The code is based upon the premise that, if the design of the pipeline is adequate for the degree of exposure of the public to the line and the line to the public in a given area, an acceptable degree of safety will be achieved and no separation distances need be specified. It is true, of course, that in order to minimize the cost of rights-of-way and of construction and in order to avoid future trouble resulting from the growth of population centers, a pipeline company will, when locating a line, locate it in as thinly populated an area as is economically feasible. When there is a choice, a pipeline company will also stay as far away from existing buildings as is feasible.

Four types of construction are specified in the code. These are:

> Type A, with a maximum operating hoop stress of 72% of the specified minimum yield strength of the pipe,
> Type B, with a maximum hoop stress of 60%,
> Type C, with a maximum operating hoop stress of 50%, and
> Type D, with a maximum operating hoop stress of 40%.

Generally speaking, the type of construction prescribed by the code depends upon the population density in the area in which the pipeline is to be located. There are many exceptions to this general rule, however, as for example in certain areas where pipelines cross highways for railroads or are located on bridges. Again ignoring a number of important exceptions, it can be stated that the 72% of yield stress level is permitted in wastelands, deserts, mountainous areas, grazing land, and farm land, provided the population density index does not exceed the value specified in the code.

The 60% of yield stress level is prescribed for areas where the degree of development is intermediate between the sparsely settled areas just described and city conditions. Fringe areas around cities and towns fall in this class. The 50% of yield stress level construction is prescribed for areas subdivided for residential or commercial purposes where at the time of construction of the pipeline 10% or more of the lots abutting on the street or right-of-way in which the pipe is to be located are built upon. The 40% of yield stress level design is prescribed for construction in large city streets where heavy traffic, many underground structures, and multi-story buildings predominate.

Thus, we see that the new code sets up four location classes and four types of construction whereas the old code had two location classes and two types of construction. While the new code is more complex, it conforms more closely than did the old code to actual practice in the industry, and is, I believe, based on very sound principles.

While it is generally true that the code limits the maximum operating hoop stress to a stated percentage of the specified minimum yield strength of the pipe, there are many exceptions to this general rule. For example, if furnace lap-weld or furnace butt-welded pipe, or pipe manufactured to ASTM specifications A 134 or A 139 is used, a joint de-rating factor must be applied. Furthermore, the maximum operating pressure of a pipeline is limited by the code to 60% of the mill test pressure for furnace butt welded pipe or 85% of the mill test pressure for all other pipe. Generally speaking, used pipe or pipe of unknown origin cannot be used at the maximum stress levels permitted for new pipe made in accordance with approved specifications.

The maximum stress levels to which used or unidentified pipe can be used are prescribed in the code. Fabricated assemblies, such as mainline connections for separators, mainline valve assemblies, cross connections, river crossing headers, etc., installed in Class 1 locations (sparsely located) are to be designed for a maximum operating hoop stress of 60% of the specified minimum yield strength of the pipe.

Part 6 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

Corrosivity of gases and soils and the prevention of over-pressuring
***GAS* — June, 1955**

This article continues the discussion started last month on Chapter IV of ASA B31.1 Section 8—Gas Transmission and Distribution Piping.

The stress levels and design procedures for pipelines prescribed by the code are all based upon the assumption that the gas to be transported is substantially non-corrosive and either the soil in which the pipe is installed is substantially non-corrosive or suitable steps are taken to prevent corrosion. The code prescribes that, if a corrosive gas is to be transported or if suitable means of preventing corrosion in corrosive soils are not to be provided, the thickness of the pipe shall be increased to provide an allowance for corrosion. In such cases, the minimum corrosion allowance shall not be less than 0.050 in. for external corrosion and .0075 in. for internal corrosion. If both external and internal corrosion are to be expected, both allowances are to be added. No corrosion allowances are required in piping to be operated at stress levels of 20% of the specified minimum yield strength or less. However, the code states that the installation in corrosive soil of unprotected pipe with wall thicknesses as thin as the minimums permitted by the code is not recommended even for low pressure distribution systems.

Non-corrosive gas

Getting back to corrosion allowances for high pressure transmission lines, questions naturally arise as to what is a substantially non-corrosive gas and what is a substantially non-corrosive soil. In answer to the first question, the code says, "For the purpose of this code, any fuel gas of commercial grade, the water dew point of which is at all times below pipeline temperature, shall be considered to be substantially non-corrosive unless experience with it has indicated otherwise. Some fuel gases may be substantially non-corrosive even though their water dew point exceeds pipeline temperatures. Such gas shall, however, be assumed to be non-corrosive only if proven so by careful tests or experience."

Suitable protective coating

The questions as to how to determine the corrosivity of a soil, or what is a suitable protective coating to prevent external corrosion in a given situation, are questions upon which the code committee was unable to agree. Although some types of pipe coatings are very generally used and have proven to be quite effective, very few standard specifications for either the components of protective coatings or for the design and application of a coating have been developed by recognized and authoritative specification writing bodies. Without these, the code committee found that it could not prescribe, recommend, or even mention specific coatings without running the risk of placing other coatings that might be equally good at a serious disadvantage.

The use of cathodic protection, or the possibility of its use, further complicates the code-writing problem. A protective coating that might be quite inadequate without cathodic protection might be sufficient with cathodic protection, providing the cathodic protection is applied skillfully and with continuing qualified supervision. Consequently, the code committee has had to limit itself to requiring that, if stress levels approaching the maximum permitted by the code are used, corrosion must be held to very minor proportions. The methods by which this is accomplished are left to the owner.

Accidental over-pressuring

The accidental over-pressuring of gas transmission or distribution facilities has led, in the past, to some serious accidents. While most accidents from this cause have occurred in distribution systems and most of the material in the code, on pressure control and pressure limiting, deals with the problems encountered in distribution systems, the code does set up some very specific requirements regarding the limiting of pressure in transmission lines. The basic requirement for protection against accidental over-pressuring is:

"Every pipeline, main, distribution system, customer's meter, and connected facilities, compressor station, pipe-type holder, bottle-type holder, container fabricated from pipe and fittings, and all special equipment, if connected to a compressor or to a gas source where the failure of pressure control or other causes might result in a pressure which exceeds the maximum allowable operating pressure of the facility, as prescribed by this code, shall be equipped with suitable pressure relieving or pressure limiting devices in accordance with the provisions of this code."

In prescribing types of devices that are suitable for preventing accidental over-pressuring, the code differentiates between the type of device required for the protection of facilities that might be bottle tight and the type of device required for the protection of facilities from which some gas is always issuing. Both must be protected. Bottle-tight facilities might include a pipeline, or a section of a pipeline between valves, in which there are no leaks or only small leaks and to which a continuous load is not connected. Another example of a bottle-type facility would be a pipe-type holder that can be shut off at times so that it is not supplying any load. Suitable types of protective devices to prevent over-pressuring of bottle-tight facilities are stated by the code to be:

a. Spring-loaded relief valves of types approved for unfired pressure vessels by the ASME, or

b. Pilot-loaded back pressure regulators used as relief valves and so designed that failure of the pilot system or control line will cause the regulator to open.

Automatic devices that shut off the supply of gas to a facility when the gas pressure reaches the set maximum can be used if some gas is always issuing from the protected facility. In such cases, leakage through the protective device while it is in the closed position cannot overpressure the protected facility.

Pressure control

The control and limiting of pressure in low- and high-pressure gas distribution systems is a more complex problem from the code-writing standpoint than that presented by transmission lines. The code recognizes that if a pipeline or distribution system is operated for a long period of years at a pressure well below the design maximum pressure and substantial corrosion has occurred during this period, there is a hazard involved in some cases in raising the operating pressure above previous maximum operating levels. Consequently, it is frequently the operating pressure history of a pipeline, main, or distribution system, rather than design pressure, that determines the pressure at which over-pressure protective devices should be set to act. In such cases, the maximum safe pressure is left to the judgment of the operating company. The only code requirements being that the operating company, having decided the maximum pressure it considers safe, shall install over-pressure protective devices to prevent accidentally exceeding that safe pressure.

The code prescribes safe procedures whereby the maximum allowable operating pressure of a pipeline or distribution system can be raised to a new maximum in those cases where past practices and physical condition rather than design, determine the maximum allowable working pressure.

The code also prescribes safety precautions to be taken when a low-pressure distribution system is converted to a high-pressure system.

The accidental over-pressuring of low-pressure distribution systems has caused some of the most serious accidents in the gas industry. Consequently, the code committee gave special attention to this problem.

In this case, of course, the major hazard comes from the over-gassing of appliances and the rupture of tin meters. The code prescribes that the pressure on low-pressure distribution systems shall not exceed either: "a., A pressure which would cause the unsafe operation of any connected and properly adjusted low pressure gas burning equipment or, b., A pressure of 2 psig." Either relief valves or shutoff devices (which interrupt the flow of gas to a system when the pressure on the system exceeds a specified amount) are acceptable means of preventing over-pressure.

Detailed analysis

The code, or course, does not attempt to spell out the detailed engineering analysis that is often required to verify that a low-pressure distribution system is adequately protected from accidental over-pressuring. Large distribution systems are usually supplied with gas from a number of pressure-regulating stations. It is sometimes assumed that if one regulator feeding the system sticks in an open position this will merely result in raising the pressure on the distribution system to the point where other regulators shut off and the load on the system will then absorb the excessive flow through the stuck regulator, and that the highest pressure attained on the system will be safe. While this may sometimes be true, the validity of such an assumption should be carefully tested in all cases by comparing the delivery capacity to the stuck regulator with the capacity of the low-pressure system to carry gas away from the stuck regulator. Usually when such a study is made, it becomes apparent that a zone of high pressure would build up around the stuck regulator and in that zone the pressure would be high enough to exceed the limit set by the code. It is also necessary, of course, to consider the possibility that valves in lines that interconnect high and low-pressure systems might be opened by mistake and the capacity of the low-pressure system to carry gas away from the valve is inadequate to prevent the development of a high-pressure zone in the vicinity of the valve.

Varied situations

The different types of accidents or situations that have resulted in the accidental over-pressuring of a low pressure system have been so varied in the past that considerable study and care is necessary in each system to make sure that low pressure systems are adequately protected. One very important precaution that is stipulated by the code is that protective devices must be designed and located where an accident which causes the malfunctioning of a pressure regulator, will not also make the protective device inoperative.

The code also covers in some detail precautions that should be taken to prevent the accidental over-pressuring of meters and customers' facilities that are supplied from high pressure gas distribution systems. Certain specific requirements for house-type regulators are stated. In those cases where customers are supplied from distribution systems or pipelines operating in excess of 60 psig, it is necessary to install a protective device that will prevent overpressuring of the customers' facilities in case the house-type regulator fails to shut off. Types of devices that the code committee considers suitable for this purpose are monitoring regulators, relief valves, or automatic shutoff devices.

Part 7 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

Construction and testing methods
Chapter 4 stresses good specifications, close inspection
***GAS* — July, 1955**

The May and June installments in this series on the new code covered design practice as set forth in Chapter 4. Before dispensing with that chapter, let us consider the provisions regarding the construction and testing of pipelines and mains (Sections 841.2, 841.3, and 841.4).

The first requirement of the code pertaining to construction is that written specifications shall be provided for all construction of pipelines and mains. While one provision of such specifications could be that the work shall be done in accordance with Section 8 of the Pressure Piping Code, the code itself is not intended to serve as a set of specifications In many cases, the code prescribes acceptable alternate practices. Specifications should designate the particular practice the owner wishes to use. The code does not include many things that should be spelled out in specifications that are to be part of an agreement between the owner and the contractor. Usually, it is also desirable that such items be spelled out in specifications that are to be used by the owner's own crews. The code does not imply, of course, that a separate set of specifications be written for each job. Often, standard specifications with additions or insertions to fit specific job requirements can be used.

Owners who wish to keep their records so that they provide good evidence that work has been done in accordance with the code can either file in the job file a copy of the specifications under which the job was built or can make reference there to the standard specifications that were used.

The code recommends that the construction specifications used shall cover all phases of the work and shall be in sufficient detail to cover the requirements of the code. The development of a good set of specifications, with follow-up and inspection to assure those in responsible charge of the work that the specifications are being complied with, is, of course, widely recognized as a necessary management procedure to assure sound construction and safety, regardless of whether the work is done by outside contractors or company crews.

A study of the records of past pipeline failures leads to the conclusion that many failures are the result of inadequate inspection during construction.

Our past discussions of pipe specifications and the inspection of pipe at the pipe mill emphasized the great importance of eliminating notches and scratches. It can probably be safely said that most failures of pipelines that have involved the actual bursting of the pipe at pressures below that required to stress the pipe to its specified minimum tensile strength start in a notch or groove or crack. These may be defects in longitudinal or round seam welds or they may be defects in the plate. Such defects produce triaxial stresses in the plate in the immediate vicinity of the notch and cause the plate to fail in a brittle manner. Such defects are especially serious at low temperatures and in the less ductile or notch-sensitive steels.

Cold working tends to produce notch sensitivity; consequently, if the groove or notch is caused by a blunt instrument, which also dents or deforms the steel and thus in effect cold works the steel in the immediate vicinity of the notch, an especially dangerous defect is the result. If a bulldozer blade or tractor track notches a pipe it usually also cold works the plate in the vicinity of the notch and, if so, pipeline failures of the brittle type sometimes result.

It is evident from this discussion, I think, that one of the major objectives of an inspection organization on a pipeline job is to see to it that the pipeline gets into the ground and is safely covered up without having any scratches or notches inflicted during the construction period, and that no pipe goes into the pipeline carrying such defects as a result of mishandling either in the pipe mill or during transportation. Even after a pipeline is covered by backfill it is sometimes damaged by construction equipment sinking through wet backfill and gouging the pipe.

Procedures are prescribed in the code for eliminating notches and grooves when they are found in pipe in the field. Such defects can be removed by grinding, providing the resulting wall thickness is not less than the minimum prescribed by the code for the conditions of usage. When deeper grinding would be required the damaged portion of pipe must be cut out of the line and a new cylindrical section installed in its place. Any welding or patching of gouges and grooves is prohibited.

Dents that are more than ¼-in. deep must be removed by cutting out a section of pipe and replacing it with a new cylindrical section.

Sections of pipe containing arc burns must be cut out and replaced with a new cylindrical section, unless the metallurgical notch caused by the arc burn can be completely removed by grinding without reducing the pipe wall thickness below the minimum specified.

The amount of inspection required on a pipeline job, and the number of inspectors necessary to do an adequate inspection job, are questions that are not answered by the code because, of course, general answers are not possible. The former depends upon the know-how and reliability of the organization doing the construction work and upon the integrity of the individuals involved. The number of inspectors on a big inch pipeline spread usually varies from two to ten. The smaller figure is probably never adequate and even the larger figure may be inadequate at times.

In addition to detecting notches and scratches and similar defects, the field inspection organization is concerned with other factors that affect the safety of the pipeline, such as welding inspection, coating inspection, and the inspection of bending operations. Lowering-in and backfilling also require adequate inspection. The code does not attempt to spell out in detail just what inspection operations are necessary but does give some suggestions that the committee thought would be helpful as indicators of the intensity and quality of the inspection that the committee has in mind.

The code devotes considerable attention to pipe bends. Here, again, excessive cold working of the pipe is undesirable. Long-radius cold bends made in the field under properly controlled conditions are considered to be satisfactory form this standpoint. However, bends that deform the pipe from its cylindrical shape or cause excessive localized cold working by buckling or wrinkling are not acceptable. Cold wrinkle bends are in the words of the code, “permitted but not preferred on systems operating at 40% or more of the specified minimum yield strength of the pipe.” Cold wrinkle bends, of course, cause a great deal more cold working of the metal at the wrinkle than occurs at any point in a long-radius smooth bend. The code cautions against wrinkle bends that have sharp curved surfaces or wrinkles that are placed on the pipe across the longitudinal seam. Such wrinkles are prolific sources of trouble.

Mitered bends are not approved for pipelines operating at 40% or more of the specified minimum yield strength of the pipe. However, mitered deflections up to 3 degrees, even in such high pressure pipe, are permitted.

Larger mitered angles are permitted for pipelines operating at lower pressures. A 90° miter is permissible in systems operating at 10% of the specified minimum yield strength or less. The chief objection to small angle miters made in the field is the difficulty of getting a good match-up that will permit making a weld comparable in quality to the other welds in the pipeline.

The code discusses in some detail precautions necessary to avoid explosions of gas-air mixtures or uncontrolled fires during construction operations. In general, elaborate purging procedures, such as those described in the American Gas Association Purging Manual, are not required. It does point out certain specific cases, however, where such purging procedures are necessary.

The testing of gas transmission and distribution piping, after construction is completed but before the pipe is placed in operation, was probably given more attention by the committee than any other subject. The test requirements finally adopted by the committee represented a considerable departure from the testing provisions of old Section 8. That section stated that gas transmission lines must be capable of withstanding a test pressure 50 psi higher than the maximum pressure at which the line is to be operated. This was interpreted by many companies as not requiring a field test. Consequently, it was quite general practice in the gas industry to place high pressure pipelines in operation without prior testing to prove strength.

The committee early adopted the policy that all facilities must be tested before they are placed in operation. From the standpoint of testing requirements, the code divides piping into three categories: The highest pressure category piping that operates above 30% of the specified minimum yield strength of the pipe; the intermediate pressure category, pipe that operates at less than 30% of the specified minimum yield strength of the pipe, but at more than 100 psi; and the lowest pressure category, piping that operates at less than 100 psi.

The code requires that piping falling in all three categories must be tested for leakage before placing in operation. All piping in the intermediate pressure category, except piping in location Class 1, must be tested to prove strength.

The use of gas as a test medium for high pressure pipelines is greatly restricted in the new code, insofar as tests to prove strength are concerned. Gas can be used for this purpose only in pipelines located in location Class 1, which is the least populated of the four location classes into which all gas piping locations are divided in the code. The use of gas in location Class 1 is further restricted by paragraph 841.5 of the code, which states, “All testing of pipelines and mains after construction shall be done with due regard for the safety of employees and the public during the test. When air or gas is used, suitable steps shall be taken to keep persons not working on the testing operations out of the testing areas during the period in which the hoop stress is first raised from 50% of the specified minimum yield strength to the maximum test stress, and until the pressure is reduced to the maximum operating pressure.”

Since a pipeline designed to operate at the maximum pressure permissible by the code in location Class 1 would normally be tested to 79.2% of the minimum yield strength if gas is used, this paragraph of the code requires that if the testing is done with gas, the public shall be removed from the test area to a safe location for a period of perhaps several hours. If the public cannot be kept at a safe distance from the pipeline during the test, water must be used as the test medium. Pipelines in location Class 2 (fringe areas around cities and towns and the more densely populated rural areas) can be tested under the code with air or water. High pressure pipelines in towns and cities must be tested with water.

The code requires a minimum test pressure that shall be used to prove the strength of pipelines and mains in all four location classes. It also prescribes the maximum test pressure that may be used if air or gas is

used as the test medium. The committee felt that the setting for maximum test pressure is necessary to avoid excessive hazards of life and property during the test. No maximum test pressure is prescribed if water is used as the test medium.
The practice of companies using water for testing varies a great deal. Some use as the test pressure the minimum prescribed by the code; others use pressures high enough to cause some actual yielding of the weakest pipe in the section under test.

The strength test provisions of the new code are quite lengthy and include special requirements to meet special conditions that are sometimes encountered during the testing of pipelines and mains. For example, requirements for hydrostatic testing are modified in situations where water of unsatisfactory quality is not available in sufficient quantities or in cases where testing must be done during period when the ground temperature is below 32°F, or in situations where there is danger that the ground temperature might drop to32° or less during the test. The code also requires that, "The operating company shall maintain in its file for the useful life of each pipeline and main records showing the type of fluid used for test and test pressure."

In addition to the tests required to prove strength, all transmission lines and mains must be leak-tested before they are placed in operation.

Part 8 in a Series
The New Gas Transmission and Distribution Piping Code (ASA-B31-Section 8)

Code's outline is pattern for top-managed maintenance plan
***GAS* — September, 1955**

In this eighth and final article in our series on the new ASA Gas Transmission and Distribution Facility Code, the section of Chapter 4 on pipe-type holders and Chapter 5, on operating and maintenance procedures for gas transmission and distribution facilities will be discussed.

The code defines and provides for two types of holders, which, because of their design and the materials used in their construction, are closely related to pipelines. These are defined in the code as follows:

"1. A pipe-type holder is any pipe container or group of interconnected pipe containers installed at one location and used for the sole purpose of storing gas. A pipe container is a gas-tight structure assembled in a shop or in the field from pipe and end enclosures. 2. A bottle-type holder is any bottle or group of interconnected bottles installed in one location and used for the sole purpose of storing gas. Bottle, as used in this code, is a gas-tight structure completely fabricated from pipe with integral drawn, forged or spun-end encloses, and fabricated and tested in the manufacturer's plant."

Probably the most important code matter relating to holders of this type is the question as to whether they should be designed and constructed in accordance with one of the pressure vessel codes, or in accordance with the gas pipeline code. It was concluded by Subcommittee 8 that the design, construction, and testing should be in accordance with applicable provisions of the pipeline code rather than in accordance with the pressure vessel codes.

The basic reasons for this decision are:

1. If holders of this type are installed underground as required by Section 8, then all conditions of use are exactly comparable to the conditions of use of a pipeline installed in a comparable location. Consequently, the pipeline code fits more closely the conditions encountered in the construction and operation of these holders than does the pressure vessel code.

2. There are some important differences between the conditions assumed when a pressure vessel is designed and the conditions that can be assumed when a pipe- or bottle-type holder is designed. (a) Since the pipe- and bottle-type holders are installed underground they are less subject to fire and damage from falling objects. (b) When such a holder is designed, its exact location is known; consequently, the design can be made to fit the degree to which the public is exposed to holder hazards and the degree to which the holder is exposed to damage resulting from activities of the public. On the other hand, it is necessary to assume in the drafting of the pressure vessel codes that a pressure vessel designed under the code might be installed where its failure would result in injury to many people and that it will be installed where there is considerable possibility of fire damage.

Sections 8 of ASA B31.1 contains a section (844) devoted entirely to pipe-type and bottle-type holders. The principal requirements of this section are:

3. The holders of this type must be installed underground.

4. If they are installed in streets or on private right-of-way where the owner does not have exclusive use and control of the land upon which the holder is located, the holders must be built in all respects in accordance with the code provisions applicable to pipelines to operate under the same pressures and in the same locations. If pipe-type or bottle-type holders are to be installed on land under the exclusive use and control of the owner, and this land is fenced, then some economies can be effected in the design of the holders under certain conditions specified in the code.

Since by definition bottle-type holders are manufactured and tested in the manufacturer's plant, the code permits the use of a steel for bottle-type holders that would not be permitted for pipe-type holders or for pipelines. This steel is a high strength steel which must be welded under carefully controlled conditions and heat treated after welding. The use of bottles made of this steel is permissible, providing all welding is done in the manufacturer's plant, and field welding on holders of this type is prohibited.

Both bottle-type and pipe-type holders are classified in the code as facilities that may, at times, be bottle tight (that is, entirely free from leakage). Consequently, devices to prevent the accidental overpressuring of the holders must conform to the code requirements for pressure-relief devices for bottle-type structures.

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Now let us proceed to a discussion of Chapter 5 of the code, which deals with operating and maintenance procedures. The question as to whether the code should contain any provisions concerning operating and maintenance procedures was one that received considerable attention. It was observed by Subcommittee 8 that all of the state codes that have been set up thus far, covering gas transmission and distribution facilities, contain requirements pertaining to operating and maintenance. Subcommittee 8 concluded, therefore, that if such provisions were not put into Section 8, the code would be considered incomplete by state and other government agencies, and such agencies would probably, in many cases, consider it necessary to supplement our code with provisions for operation and maintenance. The committee concluded, therefore, that it would be desirable for it to develop such provisions and include them in the code.

The committee quickly realized that it would be impractical to include in a national code detailed requirements concerning the operation and maintenance of gas transmission and distribution facilities. This is because of the great difference in the present condition of various systems, difference in the materials used in their construction, and different operating conditions. It is obviously possible, however, for each operating company to set up a maintenance program and operating procedures that will be well suited to its particular conditions. The basic requirement of the new code regarding operating and maintenance is perhaps unique insofar as code writing is concerned, but is nevertheless a very practical type of code provision.

The basic requirement as stated by the code is, "Each operating company having gas transmission or distribution facilities within the scope of this code shall: a. Have a plan covering operating and maintenance procedures in accordance with the purpose of this code. b. Operate and maintain its facilities in conformance with this plan. c. Keep records necessary to administer the plan properly. d. Modify the plan from time to time as experience with it dictates and as exposure of the public to the facilities and changes in operating conditions require."

The code goes on to list the type of items that should be included in a maintenance program. However, for the most part these are merely suggestions included for the purpose of developing a picture as to the magnitude and thoroughness of the maintenance program that would be considered by the committee to be adequate. A well worked-out maintenance program and a systematic statement in writing of the program is not only necessary to comply with the code, but it is necessary as a management control device in any company, particularly large companies operating over a wide geographical area. A program that systematizes maintenance work and gives management adequate control over it and that has been developed by the operating company in good faith with the intent of adequately providing for public safety as well as for other objectives that the company wishes to achieve, will put the company in compliance with the code, and will provide for a degree of maintenance that will go far toward eliminating any tendency on the part of government officials to try to spell out in detail the amount and extent of maintenance work that a company should do.

Some of the items that should be in the maintenance program, the code says, are:

For Pipelines

a. A patrolling program.

b. Periodic inspections and tests to determine if provisions made for controlling external corrosion are adequate.
c. Period inspections or tests to determine the extent of internal corrosion if there is evidence that such is occurring.
d. Corrosion control records, including cathodic protection operating data, records of surveys to determine the effectiveness of cathodic protection, and records of leaks found and leaks repaired.

For Distribution Systems

a. Periodic patrolling of mains where special hazards exist.

b. Systematic leakage surveys, the type and frequency to depend upon local conditions.

c. Procedures that will insure the proper disconnecting and sealing of services for which there is no further planned use.

For Compressor Stations

a. Approved starting, operating, and shutdown procedures that provide for safety.

b. Periodic inspection and testing of relief valves and other automatic safety devices.

c. Inspection for corrosion.

d. Approved procedures for isolating sections of pipe or equipment and purging to prevent explosions or injury during repair or construction operations in an operating station.

For Pressure-Limiting and Pressure-Regulating Stations

a. Periodic inspection and tests to determine that equipment is in good mechanical condition and adequate and set to function at the desired pressure.

For Valves

a. Valves that might be needed in an emergency should be periodically inspected and partially opened or closed to see that they are in good mechanical condition.

For Vaults

a. Period inspection and tests to see that they are adequately ventilated.

At this point I may be wandering to some extent from the subject assigned me, but I would nevertheless like to point out that compliance with a safety code is only one and possibly one of the least important benefits that a company can derive from the time and money spent to develop and set down on paper an orderly and effective maintenance program.

Such a program should not only contain step-by-step procedures for performing the operations involved and the frequency with which such operations should be performed, but it should also spell out such things as:

5. Who is responsible for the overall program.

6. Who is responsible for the proper performance of each part.

7. The records necessary to guide the progress of the program.

8. The records and reports necessary to make it possible for management to make decisions management should make.

9. Statements of policy and procedures needed so that designated supervisors can make important decisions such as when should a main be replaced rather than repaired, in the manner desired by the management.

10. Follow-up provisions to make sure that instructions are understood and are being followed by those who execute them.

Such a program can be a very effective tool of management and can

11. Make possible the accurate control of the total amount of maintenance expenditures.

12. Make sure that first things are done first.

13. Make sure that the program is economically sound.

14. Make sure that maximum benefit is obtained per dollar spent.

15. Provide statistics that indicate whether the scale of the program is keeping the overall condition of the system the same or is gradually improving it or gradually allowing it to deteriorate.

16. Give comparative cost figures to indicate the relative efficiency of various operating divisions or crews.

The code of course is not concerned with matters of this type. My point is that a basic requirement of the code can be expanded into a program that constitutes complete compliance with the code and, at the same time, puts under management control an important operation which is in many companies actually wasteful and over which management in reality has no effective control in many cases. Or conversely, a company that has taken the steps necessary to put its maintenance work under the management control that it should have, has probably by virtue of this fact already done everything that is necessary to comply with the maintenance provisions of the code.